Pollution Prevention: Region 5 Hazardous Substance Reduction On the Path to Greener Chemistry

Module 3: Proven Approaches to Performing Hazardous Substance P2 Assessments

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MODULE INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has developed a 160 slide, 4-part training module series (approximately 5 hours for the self-guided module series) that provides approaches and tools that can be used during a hazardous substance pollution prevention (P2) assessment (Module 3 of 4). This module is the result of collaboration among EPA headquarters and EPA Region 5; input from other EPA Regions is underway, and will be used to inform updated modules. This document provides key information on using this module.

This module can be used as a stand-alone training or in conjunction with EPA's other related training modules to provide a more in-depth training for P2 staff and P2 Technical Assistance Providers (TAPs) on hazardous substance reductions. The goal of this module, and the overall training series, is to inform P2 staff and P2 TAPs of proven approaches, strategies and tools that can be used during a P2 assessment to achieve increased hazardous substance reductions. To achieve this goal, EPA will increase the awareness of existing tools and approaches so they can successfully be integrated into organizational P2 assessment protocols. Each of the modules includes specific goals that will support the overall training goal and desired outcomes.

The material in this presentation should not be quoted or cited as official EPA policy. Additionally, the tools identified in this presentation are not an endorsement of, or intended to be an endorsement of any particular tool, unless it was developed by EPA.

INTENDED USERS AND TARGET AUDIENCE

This module is intended for use by P2 TAPs and State P2 staff who want to better understand existing approaches and best management practices to achieve greater hazardous substance reductions.

TRAINING MODULE OBJECTIVES

- Increase use of process analysis and process mapping to identify P2 opportunities for hazardous substance reductions
- Increase awareness of the relationship between reduced industrial water usage and hazardous substance reductions
- Increase awareness of the economic implications of hazardous substance reduction
- Increase awareness and use of various best management practices to target hazardous substances

The module begins by briefly describing how to identify waste minimization opportunities through process analysis and process mapping. Economic considerations and the effects of water usage on chemical usage are discussed. The module then highlights Minnesota case studies showing successful reduction of chemicals of concern through process and material BMPs, and lessons learned when attempting to identify a safer chemical substitution for a hazardous substance.

How to Use This Module

This module is available as a PowerPoint presentation with slides. The recommended timeframe is approximately 1hour, 30 minutes for the presentation. EPA may update and adapt the training module to reflect region-specific and state-specific issues and concerns, as well as incorporate new policy and legal considerations as they arise.

ADDITIONAL RESOURCES

University of Illinois: Illinois Sustainable Technology Center
www.istc.illinois.edu

University of Minnesota: Minnesota Technical Assistance Program
www.mntap.umn.edu

Great Lakes Regional Pollution Prevention Roundtable: Pollution Prevention Information Resource Exchange (P2RX) Helpdesk
http://www.glrppr.org/helpdesk/

MODULE AT A GLANCE

Duration and *Elapsed Time*	**Module 3 Topics**	**Pages**
45 minutes *45 minutes*	Process analysis and process mapping BMPs for reducing hazardous substances	7–25
15 minutes *60 minutes*	Economic considerations in hazardous substance reduction	26–32
30 minutes *1 hour, 30 minutes*	Best management practices to reduce the use of chemicals of concern	33–56
TOTAL TIME: 1 HOUR, 30 MINUTES		

Icon Key

Instructions
This icon means there are specific instructions for the facilitator. This content should not be read aloud.

Background Information
This icon indicates that there is background information the facilitator should be aware of when covering this topic. This information is for the facilitator only.

Say
This icon means the facilitator should read the content nearly verbatim, interjecting his/her thoughts when appropriate.

Key Point
This icon indicates an important point that the facilitator should communicate to the audience in his/her own words.

Discussion Questions
This icon means the facilitator should allow time for the audience to ask questions or the facilitator should ask the audience questions.

Multimedia
This icon indicates the facilitator will have students watch a video.

Online Resource
This icon indicates the facilitator will have students visit an online resource.

Handouts or Resource Materials
This icon indicates the facilitator will give students a handout or other resource material.

Transition
This icon indicates the facilitator will provide a transition from one topic to another.

The information shared in this presentation was authored by Dan Marsch of the Illinois Sustainable Technology Institute (ISTC), a unit of the Prairie Research Institute at the University of Illinois. The ISTC is sole proprietor of the information published in this presentation and its related content.
Green Industrial Performance Through Waste Minimization
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Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Instructions: This is the first slide of a series that focus on defining waste, proven approaches for performing hazardous substance pollution prevention assessments (including root cause analysis), and a case study that discusses economic justification.

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Subtopics

- Process analysis and process mapping BMPs for reducing hazardous substance use
- Effects of water usage on chemical usage
- Economic considerations in hazardous substance reductions

Specific Outcomes

- Increased use of process analysis and process mapping to identify P2 opportunities for hazardous substance reductions
- Increased awareness of the relationship between reduced industrial water usage and hazardous substance reductions
- Increased awareness of the economic implications of hazardous substance reduction

Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

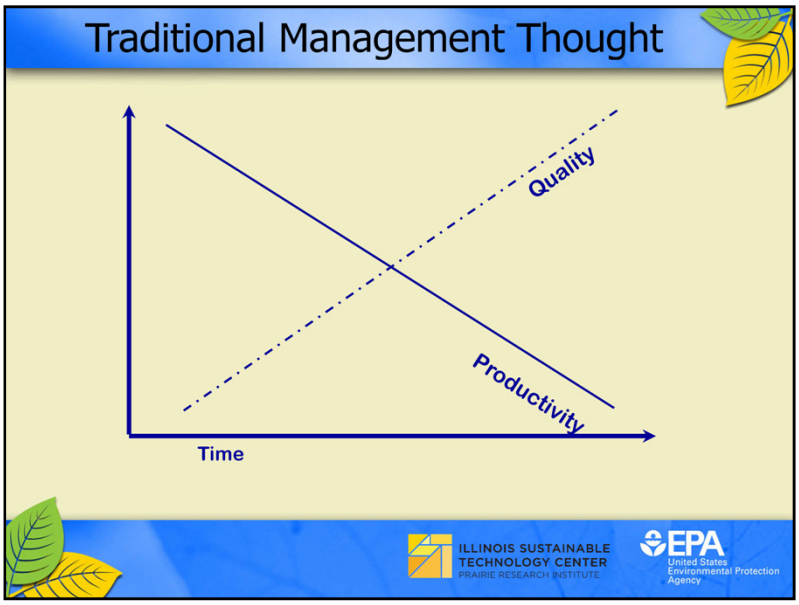
Notes for the Facilitator

Discussion Question: Waste and pollution are fundamentally what type of issue? Are they regulatory issues, environmental issues, heath issues, or economic issues?

Say: Waste and pollution are fundamentally quality issues. Waste is a defect, the result of a defective process or product; the environment is a customer, the recipient of waste and pollution. Eliminating defects to customers is what quality assurance is about. In this pursuit, quality management systems can be a useful green tool, for example Lean or Six Sigma.

Instructions: Introduce eight types of typically categorized lean waste and pollution. Highlight how natural capital is wasted; highlight the difference between understanding of natural resources and natural capital, which business understands to be more limited. How can it be wasted:

- Consumption—once you use it, it's gone. For example, raw materials, energy (fossil fuels).
- Degradation—if you neglect or overuse it, it can be degraded beyond its intended purpose, for example safe drinking water.



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

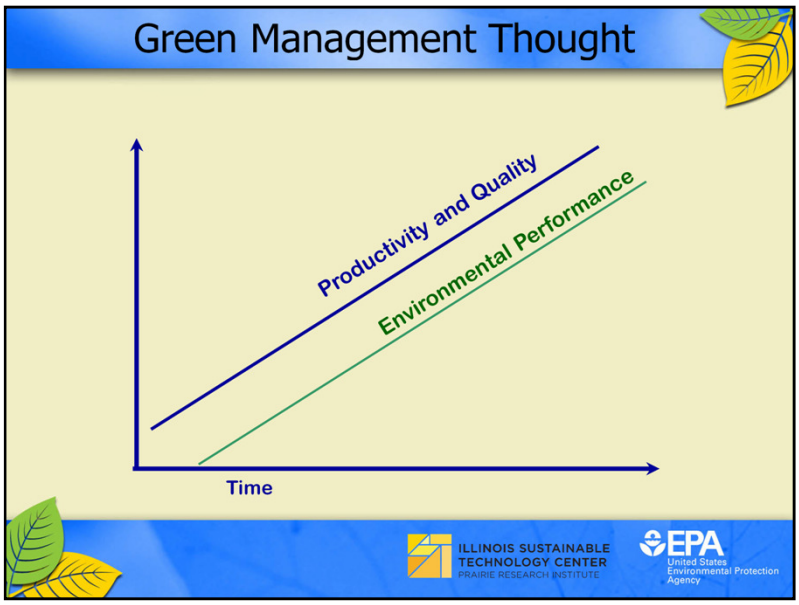
Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: This slide highlights the concept of "traditional management thought." Traditional thinking concludes that there is an inverse relationship between quality and productivity over time. You sacrifice one for the other.

Discussion Question: What is your organization's current approach to performing a hazardous substance P2 assessment?



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

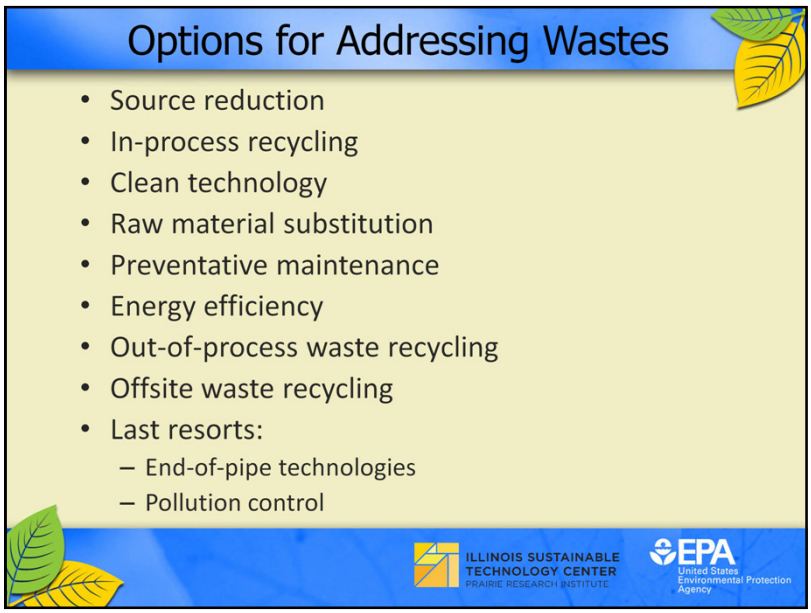
Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: This slide diagrams the concept of "green management thought" and how companies that employ a green management theory align productivity and quality with environmental performance.

Key Point: Better environmental performance for a company can result in high productivity and high quality while reducing waste and costs.



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

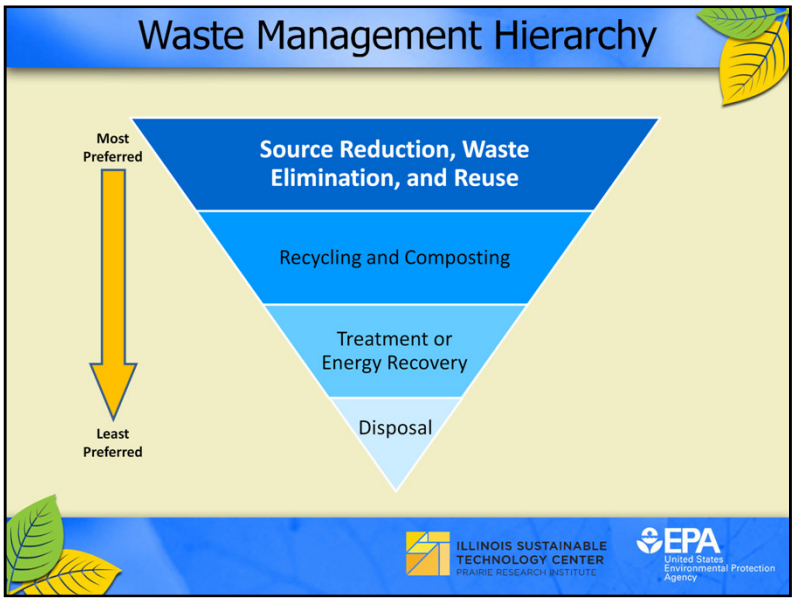
Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: This slide lists various options for addressing waste in a manufacturing process.

Instructions: Discuss each of the listed options for addressing waste. Highlight the "last resort" options, but state that the goal is to avoid these "reactionary" options.



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

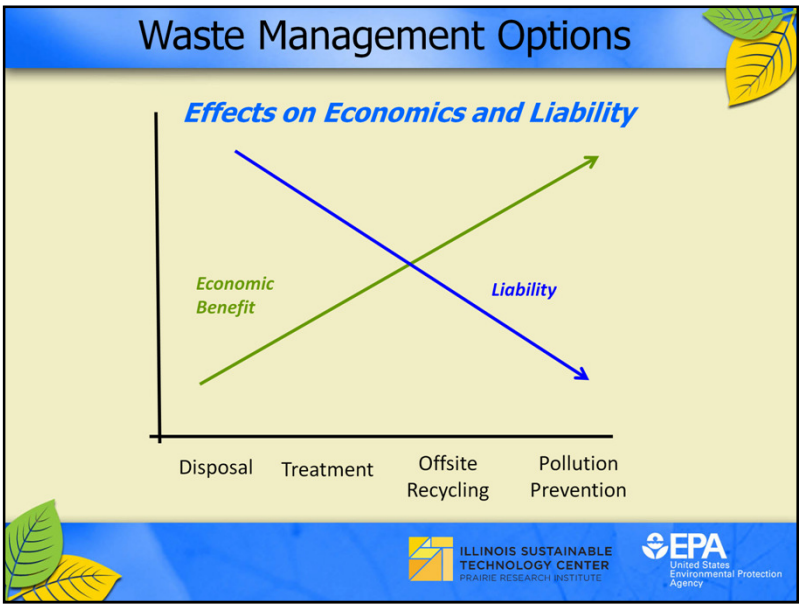
Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: The waste management hierarchy provides a visual way to show the most environmentally preferable options for waste management. It places emphasis on waste elimination, source reduction, and reuse.

Key Point: Prevention is the proactive option using source reduction to prevent or reduce waste generation.



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Process analysis and process mapping BMPs for reducing hazardous substance use
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Notes for the Facilitator

Say: Let's look at the effects on economics and liability. When we compare economics and liability to each one of they options, the reasons for their higher preference becomes more obvious. Obviously disposal has a high associated liability and really no economic benefit.

Instructions: Use this visual to explain the comparison between economic benefit and liability:

- Disposal carries a high liability and economic cost and returns little value.
- P2 offers high economic value with little or no liability since you're saving money and not generating waste in the first place.

Waste Management: Descriptive Approach
• Use quality improvement tools to solve problems associated with inefficient operations
• Used by cross-functional teams as opposed to individuals
• "Explore" processes to identify opportunities
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Notes for the Facilitator

Say: In waste management, it is important to differentiate between prescriptive and descriptive approaches. The inherent problem with prescriptive approaches is that sometime you end up solving the wrong problem, or you may end up with the wrong solution.

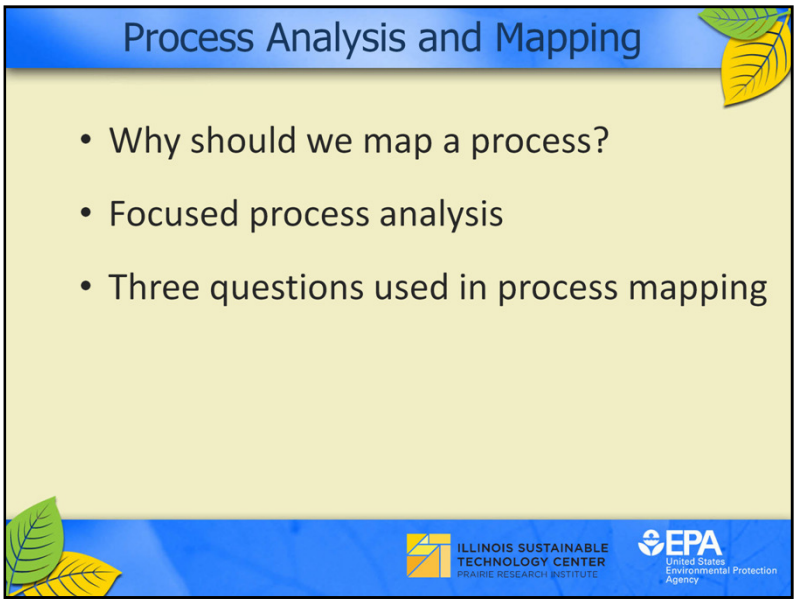
A descriptive approach, however, analyzes a process, investigates a problem, and develops a solution. In other words, quality improvement tools can be used to solve problems associated with inefficient operations. Such tools should be used by cross-functional teams (E3 assessments are a good example of a cross-functional team) as opposed to individuals in order to:

- Break down barriers created by bureaucracies.
- Involve expertise from throughout the organization.
- Creates synergy between individuals and departments.

You will often find that cross-functional teams provide an output that exceeds the sum of their individual parts.

Key Point: The take-away is to "explore" processes to identify opportunities for improvement. Analyzing processes necessitates finding the right problems, which involves process mapping.

Topic Transition: Next we will discuss process analysis, or defining the right problem to investigate.


Process Analysis and Mapping
• Why should we map a process?
• Focused process analysis
• Three questions used in process mapping
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Notes for the Facilitator

Say: Process analysis—why do we map? There is an ancient Chinese proverb that states, "When the map is complete, the route becomes more clear." Process mapping can:

1. Improve process knowledge and understanding
2. Identify and correct problem areas
3. Identify loss reduction opportunities
4. Determine usage and fate of raw materials and other resources

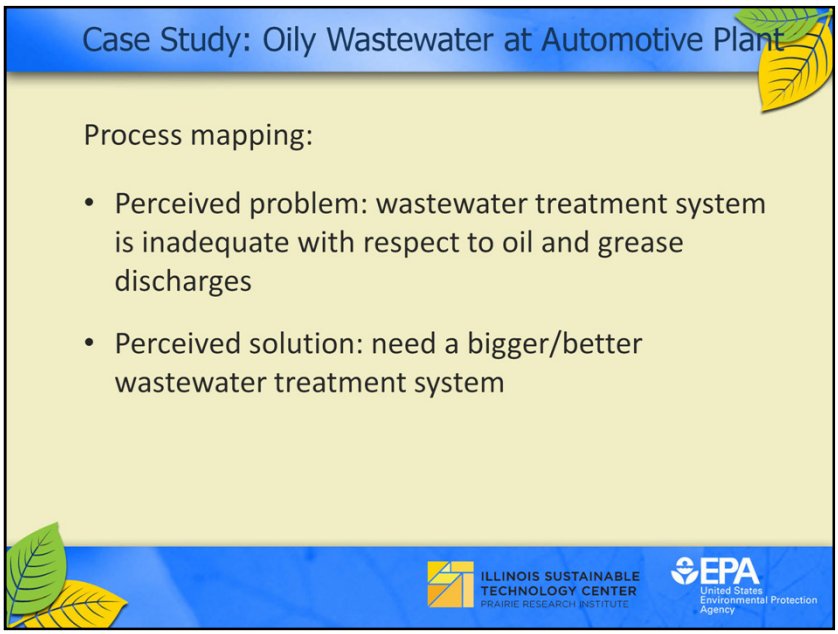
Key Point: It's important to keep a process map simple and focused. Focused process analysis allows technical assistance providers to:

1. Focus on process(es) associated with an opportunity or problem
2. Focus on inputs/outputs associated with the opportunity or problem
3. Get to the root of the problem

Once engaged in process mapping, there are three main questions:

1. What happens next?
2. What are the inputs?
3. What are the outputs?

Instructions: Repeat questions through each step of the process. It's like a broken record but eventually you will map out the whole process.


Case Study: Oily Wastewater at Automotive Plant
Process mapping:
• Perceived problem: wastewater treatment system is inadequate with respect to oil and grease discharges
• Perceived solution: need a bigger/better wastewater treatment system
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Process analysis and process mapping BMPs for reducing hazardous substance use
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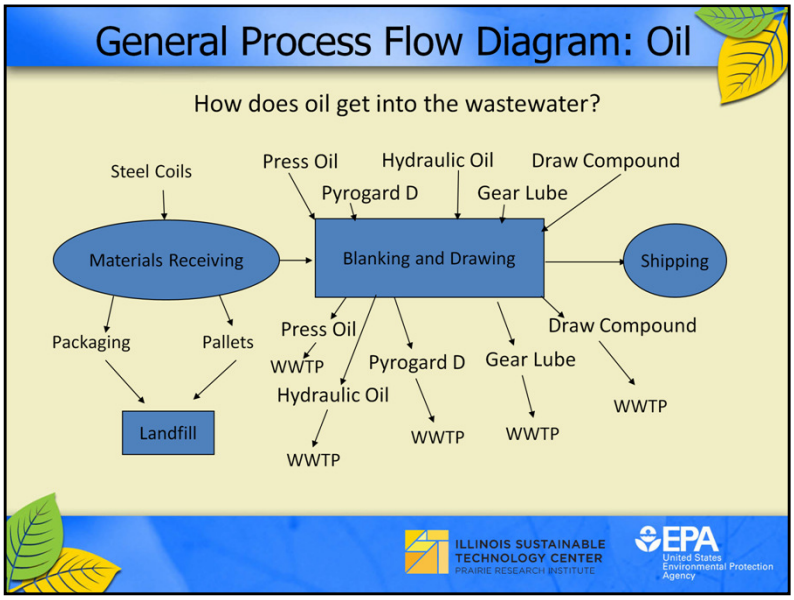
Notes for the Facilitator

Say: Consider a case study in which a metal stamping plant must effectively manage oily wastewater but the wastewater treatment plant is inadequate and the facility is being hit with charges from its utility. Eventually, the utility declines to accept the facility's wastewater, effectively shutting it down.

For this case, we assume that the plant produces 1.5 million gallons of oily wastewater per year. The wastewater is composed of 15% fats, oils, and grease. It is hauled off site at $0.18/gallon—or $270,000 annually). In analyzing this problem, the issues include:

1. The fact that the public wastewater treatment facility will not accept discharge.
2. The potential need to install or retrofit an onsite wastewater treatment system, a big ticket item.

P2: On the Path to Greener Chemistry



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

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Notes for the Facilitator

Instructions: Explain how this diagram that maps the path of oils into wastewater is animated. It first displays a standard process map. Trainees can visualize the simple, understandable production process. Clicking on the slide brings in the detailed inputs and outputs of the process and maps the paths of the hazardous chemicals to contaminated wastewater. Expand on the process using the background information below.

Investigation and analysis determined that oil reaches water mostly through leaks in presses, oil collects in basement trenches. In this case, a vendor removes oil from trenches with Super Sucker (an outside contractor) and sends it to wastewater treatment. The result: large quantities of waste that are costly and often dangerous to manage.

Background Information:
Waste: petroleum-based waste leakage from presses:
Press oil: 115,000 gallons
Hydraulic oil: 50,000 gallons
Gear lube: 30,000 gallons
PyroGard D: 30,000 gallons
Total oils in wastewater: 225,000 gallons

Defects associated with industrial fluids:

- Chemical composition
- Surfactants
- Biocides
- Contamination
- Oil, grease, dirt, metals
- Microbes
- Caustics/acids

Short-Term: Segregate and Sell Wasted Oil
• Keep about 225,000 gallons of oil out of wastewater
• Cost savings = about $240,000 annually
– Sale of waste oil
– Reduced offsite wastewater treatment
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Notes for the Facilitator

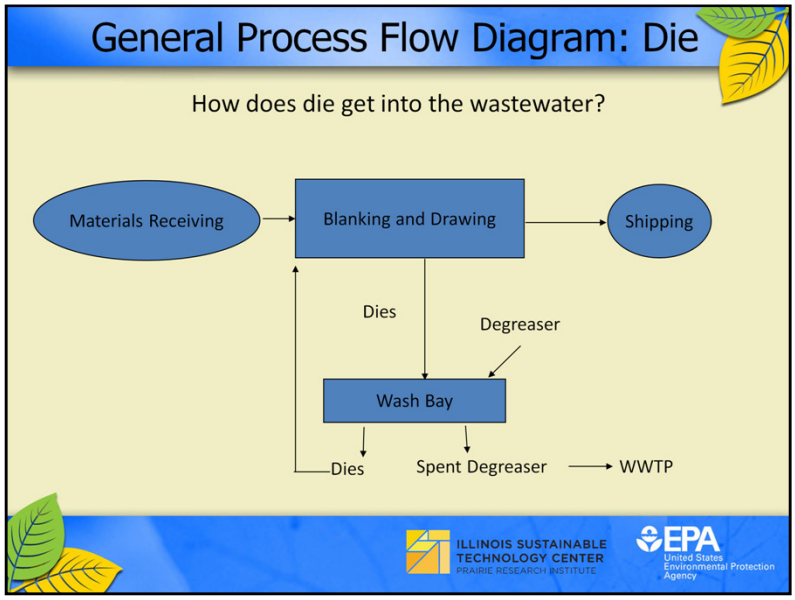
Say: A potential short-term alternative is to segregate and sell waste oil, turning the expense into a revenue. If done effectively, such a solution would keep about 225,000 gallons out of wastewater and result in $240,000 in annual savings from sale of oil and reduced wastewater treatment.

This solution assumes that the reduced oil composition in the wastewater will enable onsite treatment for remaining wastewater. A longer-term solution would be to fix the leaks in the press.

Key Point: A P2 observation is that small company obstacles tend to be technical while large company obstacles tend to be cultural. Small companies are busy and have few resources to make improvements or hire technical assistance. Large companies may suffer from behavioral silos and status quo bias.

This case study also highlights the potential for facilities to pursue initially perceived problems that differ from the real issues—the problem identified may only be a symptom of the root cause.

Root cause analysis is a quality improvement tool that establishes cause and effect and helps determine the true source of a problem.



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Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Discussion Questions : Using the same case study, how do excess oils gets into the wastewater?

Instructions: Explain the general stamping plant process map diagram, noting the separate process where the die enters the process that was not included on the original map. Include a die maintenance component: degreasing solution used for cleaning dies and other equipment = 1,300,000 gallons per year.

Subtopic

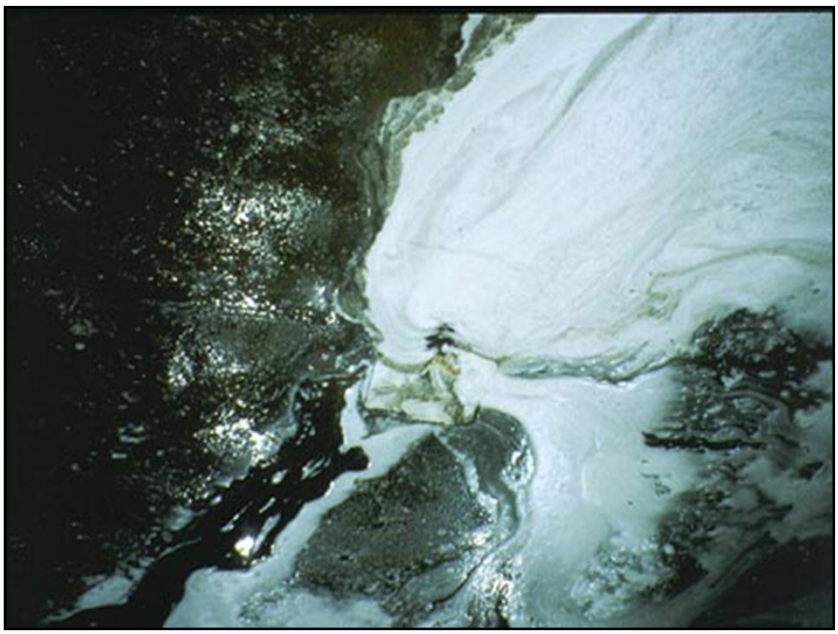
Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: This slide provides an example of the hazards and challenges presented by oily wastewater. In this process, you have large machinery, dies and press, and vast quantities of water and chemicals used to wash the oily machinery.



Subtopic

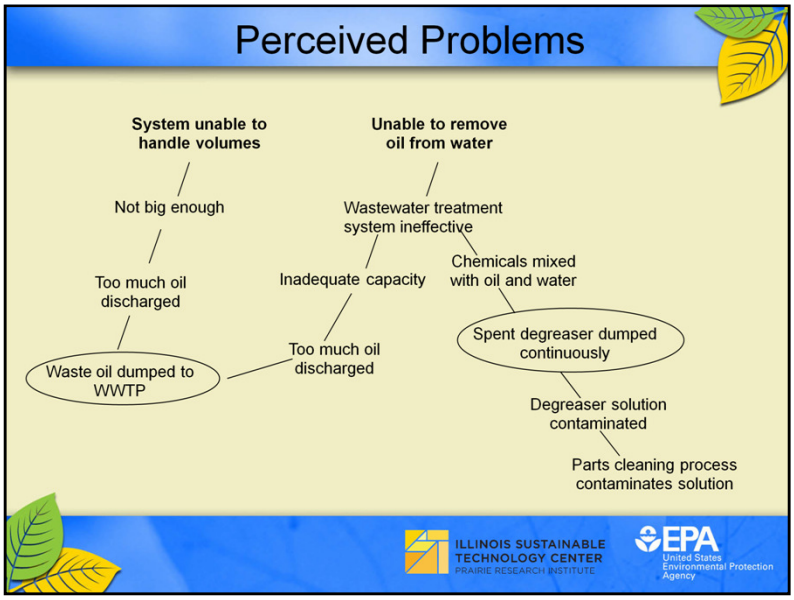
Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: This slide provides another example of the hazards and challenges presented by oily wastewater. Here oil, waste water, and wash solution are all entering the same drain.



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

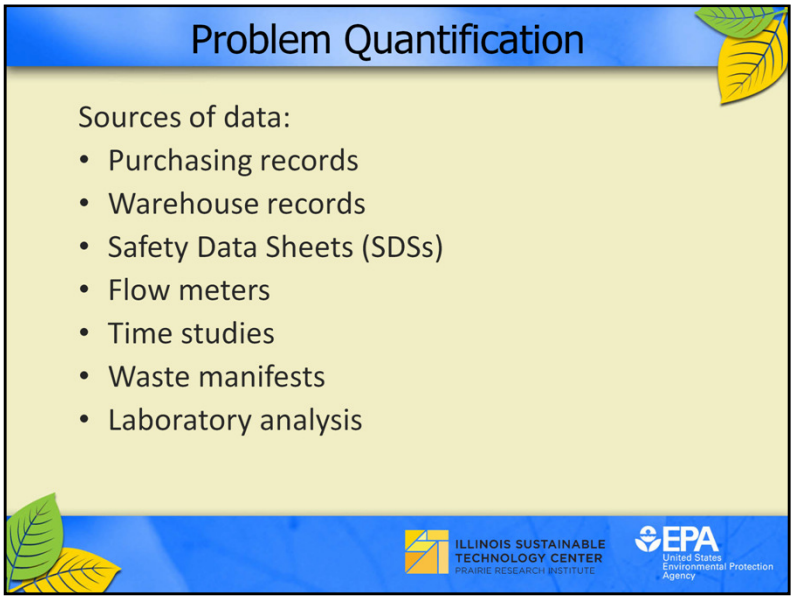
Notes for the Facilitator

Say: This slide represents the root cause analysis and highlights the issue of "perceived problems." Starting at "System unable to handle volumes," the question then becomes "why?" with a series of ensuing answers. In this case study, the wastewater treatment system is perceived to be inadequate with respect to oil and grease discharge.

In fact, the root cause is the facility's inability to remove oil from the water. Following that problem with a series of "Why?" questions leads to a different problem: "Spent degreaser dumped continuously." So, using the root cause analysis, it was determined that the perceived problem was incomplete.

Once the root cause analysis has been done and the problem has been fully identified, finding an effective pollution prevention strategy is easier. In this case study, it was determined that 1) the contractor was responsible for the over-loading at the wastewater treatment plant and 2) that the die-washing process was affecting the chemistry of the degreaser solution and rendering it ineffective. So resolving the die-washing issues would in turn resolve the wastewater treatment issues.

Using green technology, the result was a new process that reduced harmful chemical use, reclaimed and recycled the grease, eliminated waste, and avoided the need for a new wastewater treatment plant.



Subtopic

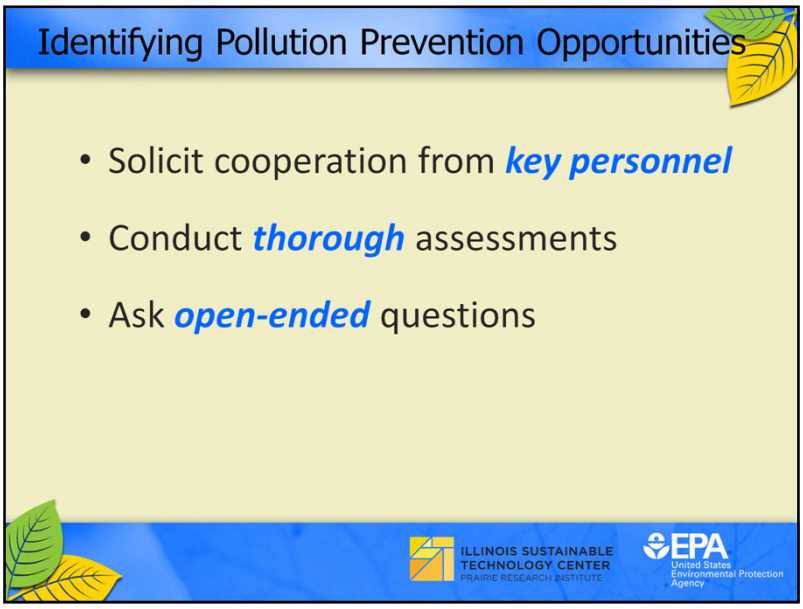
Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Instructions: Discuss the issues of quantification in P2 analysis and some useful sources of data for indentifying issues or problems.



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Say: This slide lists important components of an effective P2 assessment. It is important to have the right team members for a P2 assessment and to establish trust within the team. Key personnel for assessments can include:

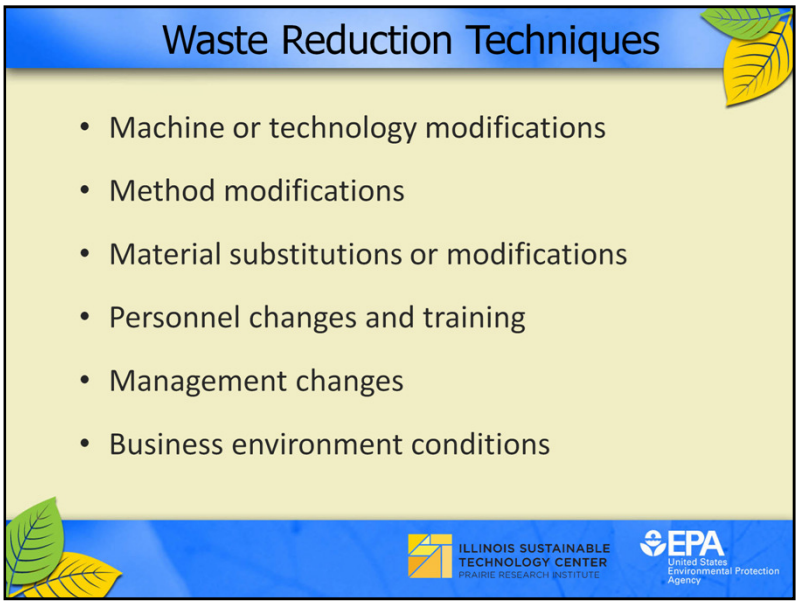
- Management or decision-makers with authority to act (the person who gets things done)
- Labor, whether union or non-union
- Line personnel, responsibility for production
- EH&S personnel to ensure regulatory compliance
- Others: purchasing, accounting, engineering, human relations, etc.

Thorough assessments are critical, it is important to examine:

- Operating procedure of workers
- Quantities of materials
- Collection and handling of waste
- Recordkeeping practices
- Leaking lines and degraded equipment
- Spill residue, smells, puddles
- Damaged containers

It is also important to ask open-ended question. Helpful assessment questions can include:

1. "Why are you using a solvent here?"
2. "Why does this material become waste? Is it contaminated with something? Has it become depleted of a critical component?"
3. "What other materials have you tried here? What were the results of your efforts?"



Subtopic

Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Instructions: List and discuss the common and effective waste reduction techniques, those that address the real problems.

Subtopic

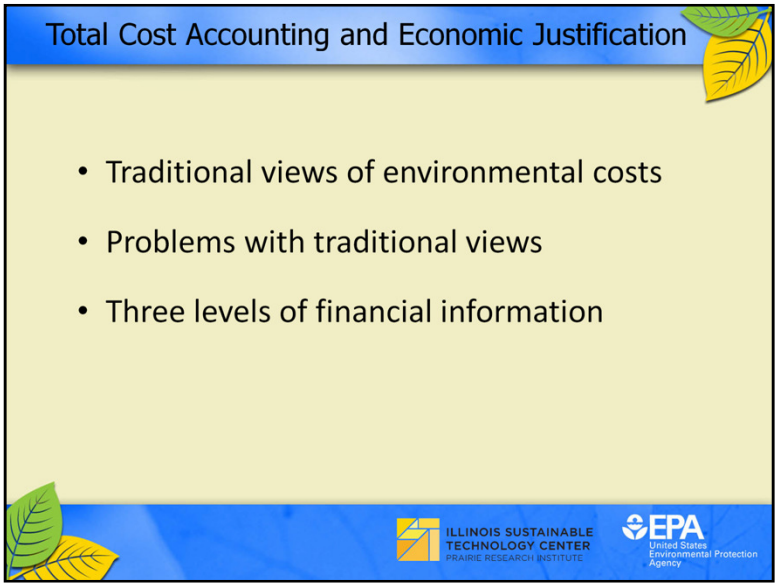
Process analysis and process mapping BMPs for reducing hazardous substance use
45 minutes

Specific Outcomes

Increased use of process analysis and process mapping to identify P2 opportunities for reducing hazardous substances

Notes for the Facilitator

Instructions: Discuss opportunities for continuous improvement of production processes and operating practices.


Total Cost Accounting and Economic Justification
• Traditional views of environmental costs
• Problems with traditional views
• Three levels of financial information
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Subtopic

Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the economic implications in hazardous substance reductions

Notes for the Facilitator

Say: Traditional views of environmental costs include:

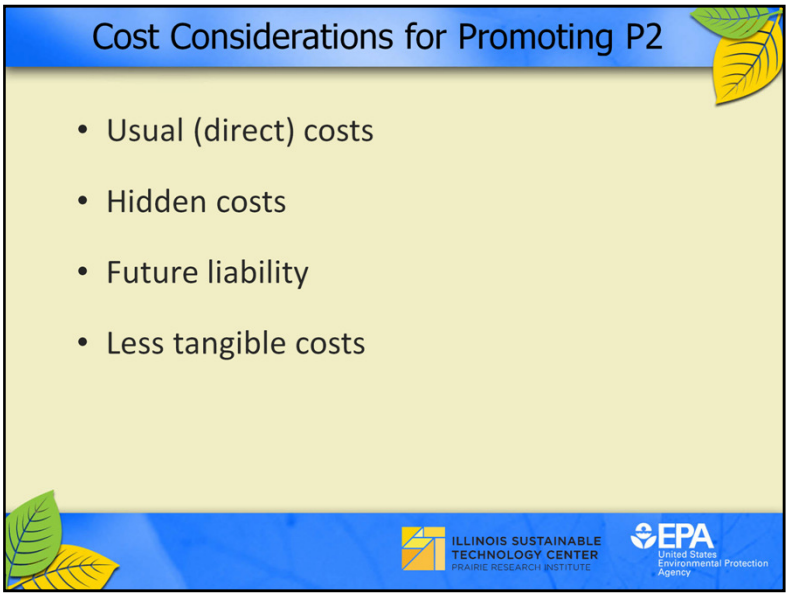
- Part of the "cost of doing business"
- Add only to overhead—reduce competitiveness
- Responsibility should fall on the environmental department/specialist
- Lumped for the entire facility/department
- Limited to transportation, treatment, storage, and disposal

However, these traditional views create problems that can include:

- Ignoring continuous improvement/innovation opportunities
- Decreased competitiveness
- Missed opportunities by not using a cross-functional approach
- Lack of incentive for change to groups and activities that generate waste don't pay for it
- Substantially underestimating the true cost of waste
- Failure to justify many P2 opportunities

Key Point: When considering total cost account and economic justification for P2, consider three levels of financial information:

1. Total cost accounting
2. Activity-based cost allocation
3. Long-term cost analysis



Subtopic

Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the economic implications in hazardous substance reductions

Notes for the Facilitator

Say: P2 cost consideration should include determining the full cost of waste, developing a cost allocation system, and developing economic justification for P2 projects.

Usual (direct) costs include direct labor, materials, equipment, waste collection, transportation, disposal, raw material consumption, production, and maintenance costs.

- Usual (direct) costs are typically the easiest to quantify and easiest to reach consensus on.
- Purchasing records are an excellent source of this info.
- Relate to process mapping or materials balance.

Hidden costs include monitoring expenses, reporting, recordkeeping, and permit requirements.

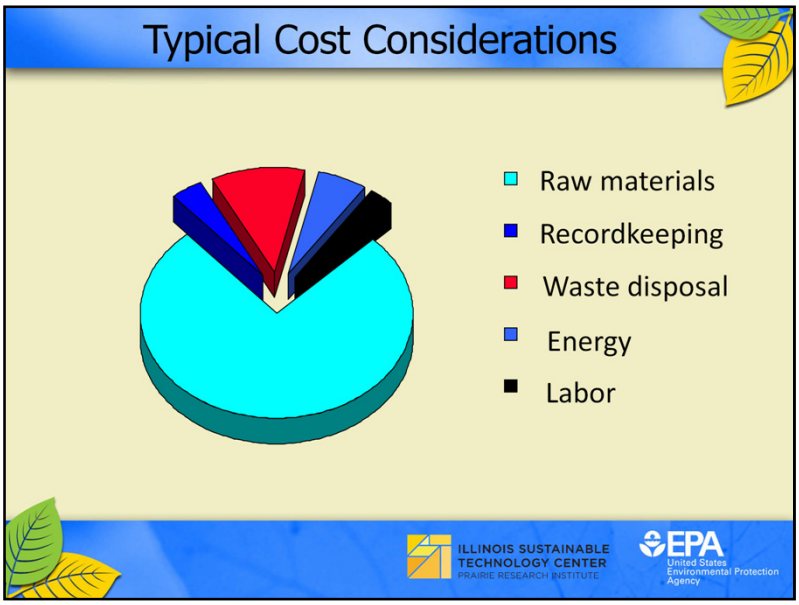
- Costs vary greatly with scale of operation and large/small-quantity generator.
- Going from large-quantity to small-quantity generator an yield significant savings.

Future liability include remedial actions, personal injury or illness to employees, personal injury or illness to the public, and property damage (to the operation and the public).

- Very difficult to predict.

Less tangible costs include consumer response to problems, employee relations, corporate image, and stockholder concerns.

- These costs are extremely difficult to quantify.
- Examples include the loss in value of stock after the Bhopal and Valdez disasters.



Subtopic

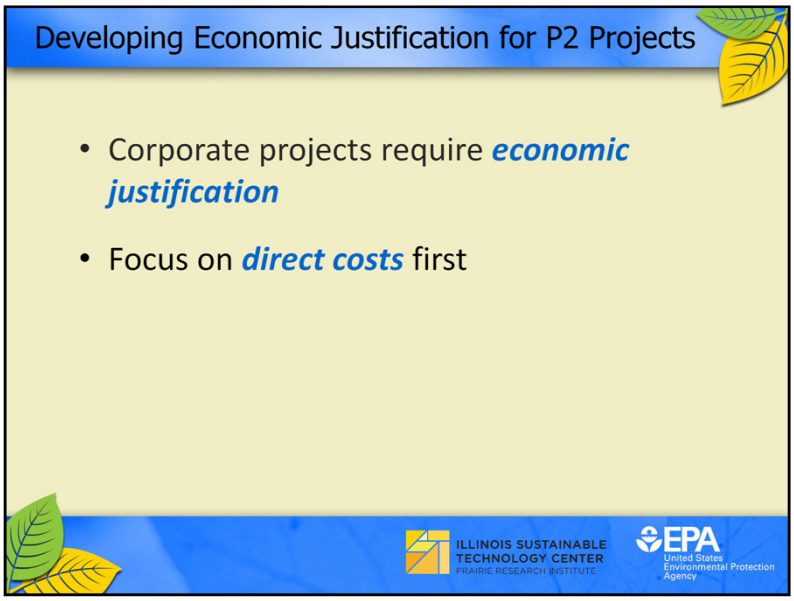
Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the economic implications in hazardous substance reductions

Notes for the Facilitator

Say: This graph depicts a generalization of typical cost considerations, with raw materials being the most significant.


Developing Economic Justification for P2 Projects
• Corporate projects require economic justification
• Focus on direct costs first
ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE
EPA
United States Environmental Protection Agency

Subtopic

Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the economic implications in hazardous substance reductions

Notes for the Facilitator

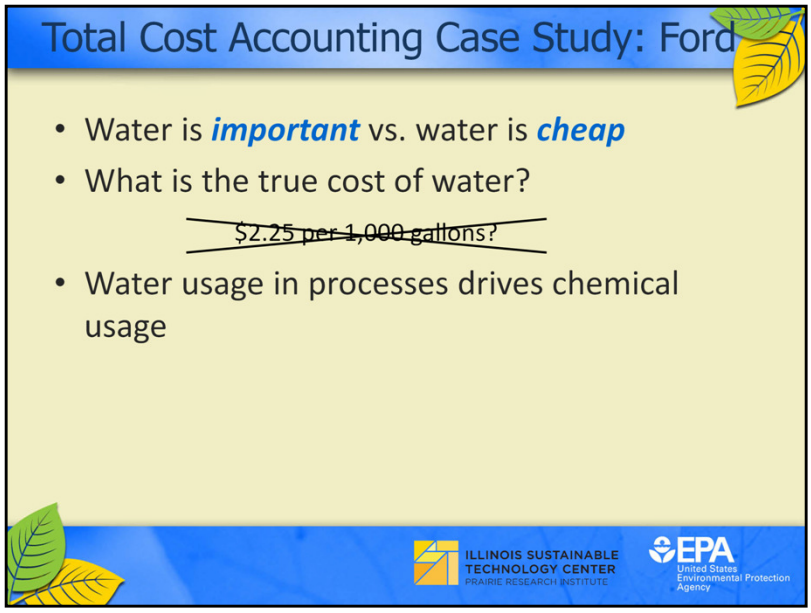
Say: Corporate projects require economic justification to gain decision-maker authorization. You will generally need to prove return on investment. When authorizing an expenditure, common economic justification topics include:

- Expansion into new markets or expand market share in current markets.
- Realize new products
- Profit-adding activities that enhance competitiveness, finance equipment purchases-reduce labor, improve quality, or reduce losses.
- Profit sustaining: activities such as maintenance and compliance costs, "must-do" and "non-discretionary activities."

Keep direct and indirect costs in mind when considering economic justification. Direct costs are most easily quantifiable and most credible. If project can be justified based on direct costs alone, stick with them. Point out that other costs exist to emphasize importance of project

Key Point: P2 activities typically minimize the importance of profit-sustaining activities and increases the visibility of profit-adding activities.

Topic Transition: Let's look at the true cost of water.


Total Cost Accounting Case Study: Ford
• Water is important vs. water is cheap
• What is the true cost of water?
$2.25 per 1,000 gallons?
• Water usage in processes drives chemical usage
ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE
EPA
United States Environmental Protection Agency

Subtopic

Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the relationship between reduced industrial water usage and hazardous substance reductions

Notes for the Facilitator

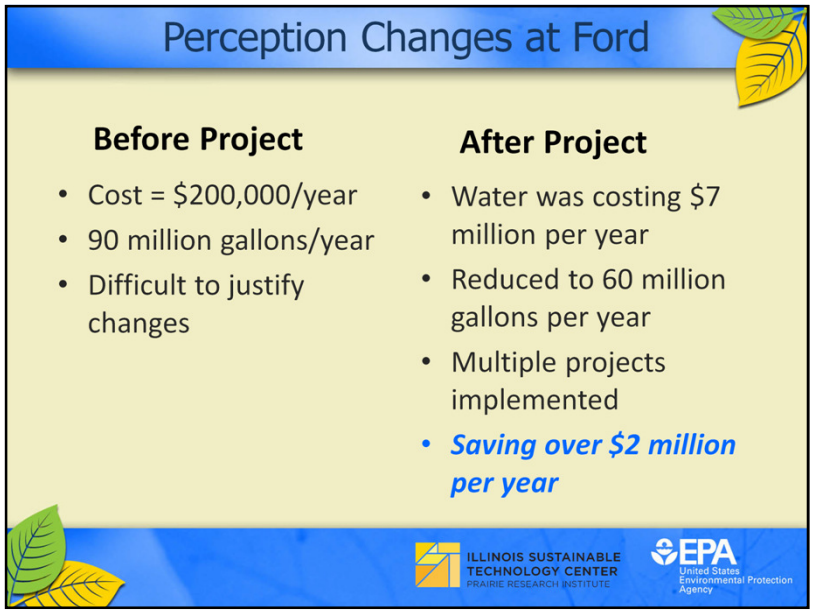
Instructions: Clicking on the slide will bring in animation that crosses out $2.25 per kilo-gallon.

Say: This is a case study that evaluated the true cost of water through a lean assessment performed at Ford's automotive assembly plant in Illinois. The assessment team included plant personnel, CMS provider, waste management provider, and several tier II suppliers. The water use was significant and reduction was not a priority. The mantra was that ***water is cheap***.

The goal of the process was to stress the idea that ***water is important***, that is it vital to nearly every step of the process and the true cost of water is not necessarily what appears on the bill. On Ford's phosphate line, water is charged at $2.25 per 1,000 gallons. Does this sound right?

Key Point: In this case study the average true cost of water is $80 per 1,000 gallons. The estimated cost of water for Ford includes the water rate for the city water utility, deionized water, WTP chemicals, process chemicals (book values), and heating energy. It does not include sewer user fees, sewer discharge fees, WTP fixed costs, and phosphate line maintenance. (In some operations, the cost was as high as $200 per 1,000 gallons)

Water usage drives chemical usage. Chemicals are metered into water based on detected levels in the water. The more chemicals you use, the more waste water you generate.



Subtopic

Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the relationship between reduced industrial water usage and hazardous substance reductions

Notes for the Facilitator

Instructions: Clicking on the slide will bring in the before and after cost and savings estimates.

Say: This slide presents a summary of the results realized following the Ford assessment.

Key Point: To summarize, the economic justification for the project was increased through technical assistance that identified opportunities to reduce water and chemical usage and improved profitability.

Additional Resources
• Illinois Sustainable Technology Center
• Great Lakes Regional Pollution Prevention Roundtable
• National Pollution Prevention Roundtable
• EPA Green Purchasing
• Waste to Profit Network
ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE
EPA
United States Environmental Protection Agency

Subtopic

Economic considerations in hazardous substance reduction
15 minutes
(Elapsed time: 60 minutes)

Specific Outcomes

Increased awareness of the economic implications in hazardous substance reductions

Notes for the Facilitator

Instructions: Explain how this slide highlights additional resources that can support hazardous substance P2 assessments.

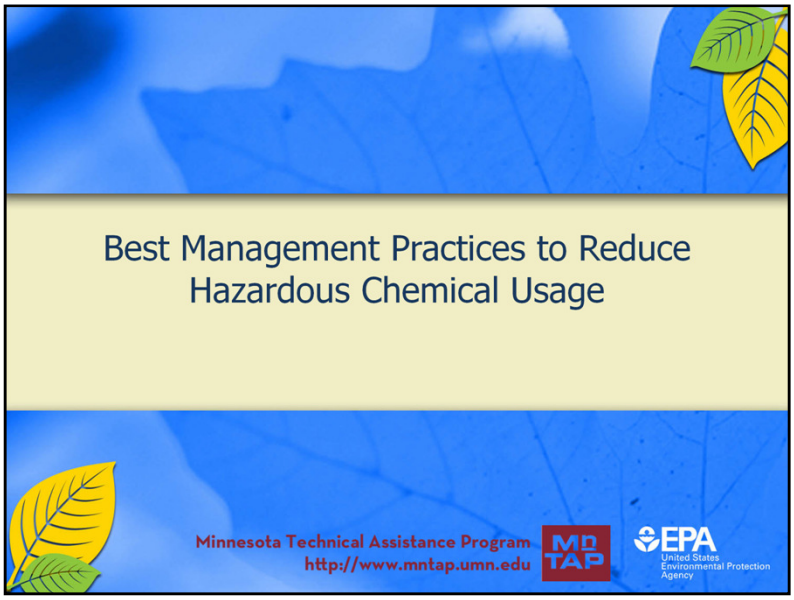
Online Resources:

Illinois Sustainable Technology Center
http://www.istc.illinois.edu/

Great Lakes Regional Pollution Prevention Roundtable
http://www.glrppr.org/

National Pollution Prevention Roundtable
http://www.p2.org/

EPA Green Purchasing
http://www.epa.gov/epp/



Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

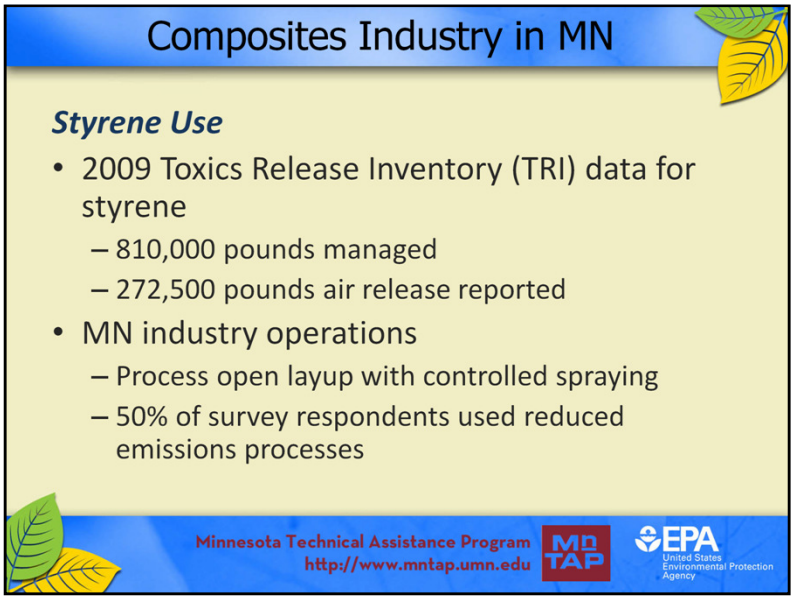
Say: This is the first slide of a series that provide case study examples of successful projects that target styrene, a chemical of significant concern in the fiber reinforced plastics industry.

Subtopics

- Best management practices to reduce the use of chemicals of concern

Specific Outcomes

- Increased awareness and use of best management practices to target hazardous substances


Composites Industry in MN
Styrene Use
• 2009 Toxics Release Inventory (TRI) data for styrene
– 810,000 pounds managed
– 272,500 pounds air release reported
• MN industry operations
– Process open layup with controlled spraying
– 50% of survey respondents used reduced emissions processes
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MN TAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

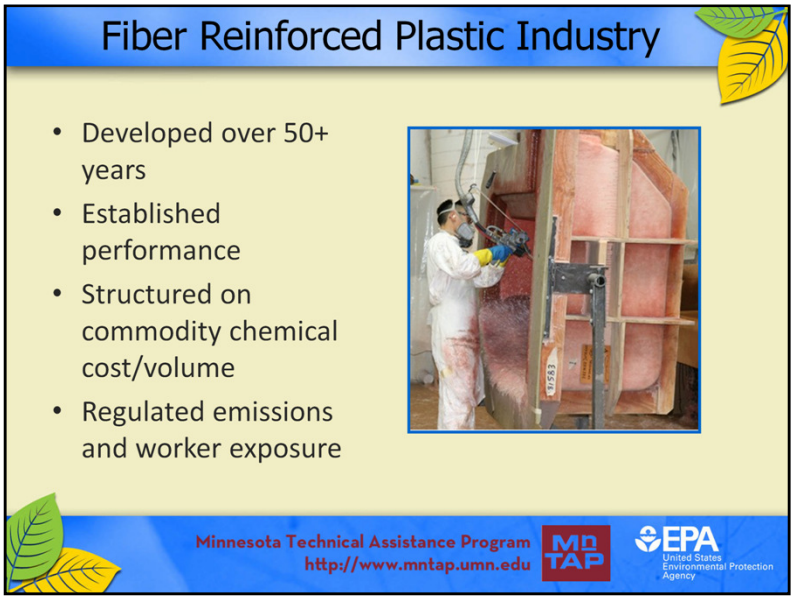
Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Say: Styrene is a hazardous air pollutant that is a critical component in many formulations in the composites industry. There are many regulations pertaining to styrene and companies using styrene have significant recordkeeping requirements. This slide shows 2009 Minnesota TRI data for styrene. Approximately 810,000 pounds of styrene waste was managed by companies, approximately one-third of this waste is being emitted into the air as an environmental release. This air release represents 272,500 pounds of raw material that is not being incorporated into finished product and is adding to the cost burden of these businesses. The release level indicates there could be considerable opportunity to better utilize the styrene containing raw materials.

These styrene releases happen because, styrene is a highly volatile component of the composites formulations and many businesses use open mold spray lay-up operations. A survey conducted in Minnesota showed that around 50% of the companies were actively implementing improved emissions practices. MnTAP has been working in the composites industry for many years and has collected many case studies that show how styrene emissions can effectively be reduced.



Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

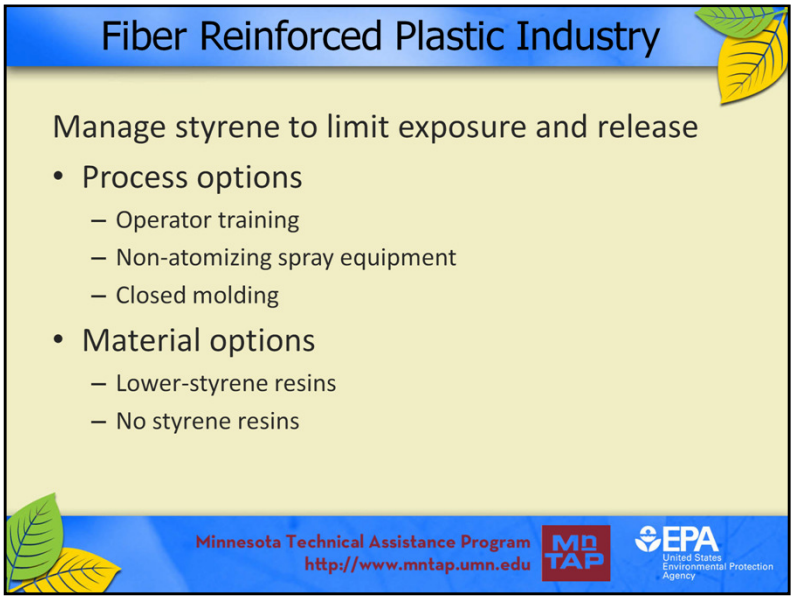
Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Say: The fiber-reinforced plastic industry is very well established, with over 50 years of development and millions of man hours of experience. Many of these companies are very knowledgeable in managing styrene, have high environmental performance, and have good reputations with customers and clients.

The industry has been structured around a commodity chemical, styrene. Commodity-based materials means they have a large volume of supply available globally and have a favorable price structure. Therefore, the industry has developed using this commodity chemical availability to establish an expectation of product performance at a favorable cost structure.

It is also common knowledge within the industry that these chemicals are regulated materials. Many emissions control strategies have been developed over the years to effectively manage this hazardous substance and minimize air releases. Many companies do this very well and continued innovation within the industry and individual companies helps manage emissions.



Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

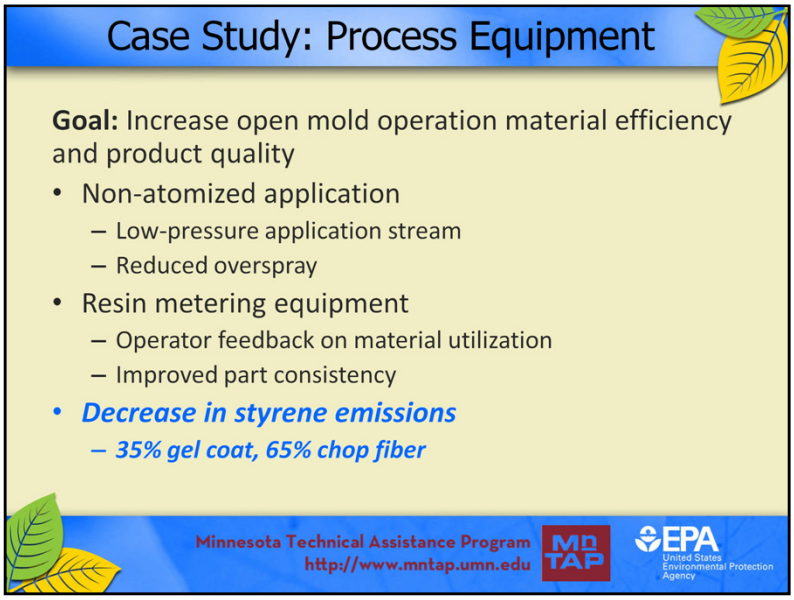
Say: The ways that fiber-reinforced plastics companies manage their hazardous materials are through process technologies such as operator training, non-atomizing spray equipment, and closed molding.

Operator training ensures that workers are spraying the material where it belongs in the most efficient manner so that material is not being wasted and they are minimizing exposure and releases.

Improved spray equipment technologies, such as non-atomizing spray equipment, reduces the surface area of the application so that there is increased directed application of materials onto the product and less loss of material during spray coating.

Closed molding operations are becoming more common in the industry. In a closed molding operation, the process takes place in a sealed enclosure where all of the evaporated material and emissions can be captured.

In addition to process technology options, there are also substitute material options that involve green chemistry. These options tend to be harder to identify in day-to-day operations, but can provide significant reductions in the use of the hazardous material resulting in significant emissions reductions when implemented.


Case Study: Process Equipment
Goal: Increase open mold operation material efficiency and product quality
• Non-atomized application
– Low-pressure application stream
– Reduced overspray
• Resin metering equipment
– Operator feedback on material utilization
– Improved part consistency
• Decrease in styrene emissions
– 35% gel coat, 65% chop fiber
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MnTAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

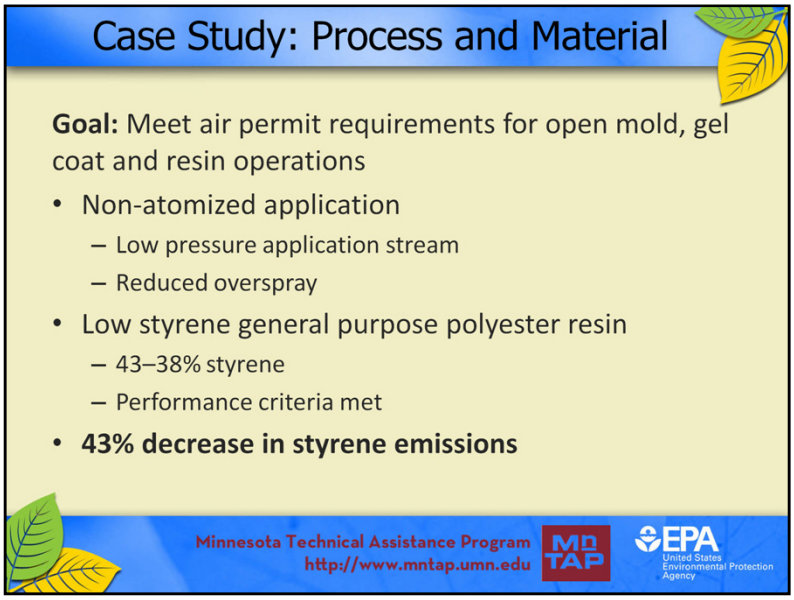
Instructions: This slide provides a case study illustrating the impact of changing the entire composites production process from open molding to closed molding on styrene emissions.

Say: A Minnesota fiberglass parts production facility was using an open mold process with traditional spray equipment. Solid waste from overspray and styrene evaporation was high. At the start of this study the company was observing almost 80,000 pounds per year of styrene emissions from its open mold processes.

The company implemented a non-atomized spray system and a real-time metering system that provided lower-pressure material application and immediate feedback to the operators on how much material had been applied to the part. There was a noticeable reduction in styrene odor from the operation during the trial, which helped drive the decision toward investment in the new equipment. The company estimated a 5% reduction in gelcoat purchases, with a styrene emissions drop from the gelcoat operations of nearly 3,400 pounds per year.

Savings in materials include $3,000 per year in gelcoat as a result of reduced overspray and $10,000 per year as a result of reduced waste from the metering system. Toxics Release Inventory and air-permit-related fees decreased by $1,700 per year because styrene emissions were reduced by 50,400 pounds.

Online Resource: A detailed case study is available at http://www.mntap.umn.edu/fiber/resources/61-FibFab.htm.


Case Study: Process and Material
Goal: Meet air permit requirements for open mold, gel coat and resin operations
• Non-atomized application
– Low pressure application stream
– Reduced overspray
• Low styrene general purpose polyester resin
– 43–38% styrene
– Performance criteria met
• 43% decrease in styrene emissions
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MnTAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

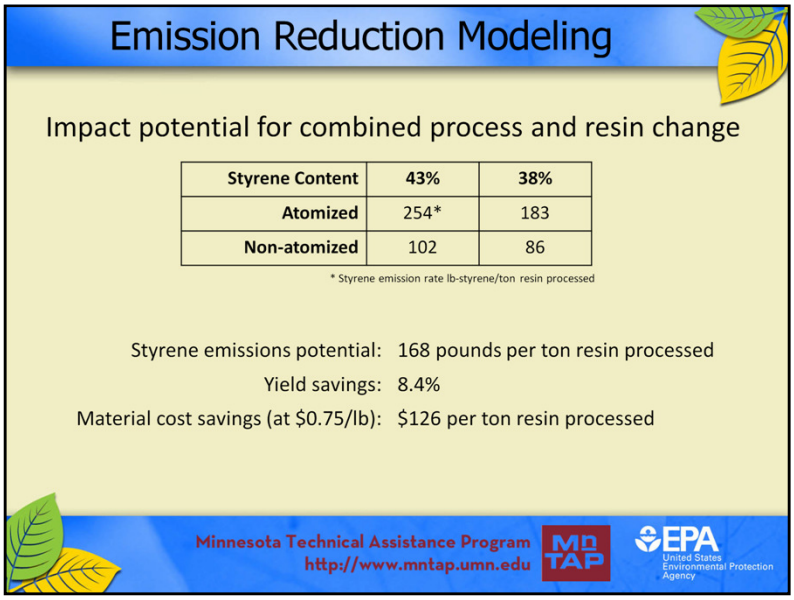
Notes for the Facilitator

Instructions: This slide provides a brief overview of a case study for Sunrise Fiberglass in Wyoming, Minnesota. The example provides a case study illustrating the impact of equipment changes and resin styrene content reduction on styrene emissions.

Say: This company needed to reduce styrene emission to comply with a new air permit. Two changes were made within the operation, use of non-atomized spray equipment and use of resins with a lower styrene content. The resin change was from 43% styrene in the resin composition to 38% styrene. The lower-styrene-content resin had a higher viscosity and required addition of an in-line heater to maintain resin temperature for optimal material flow.

Due to improvements made, the company reduced its styrene emissions by 43%. Total styrene emissions were reduced by more than 15,000 pounds per year. Material savings in excess of $12,000 per year were achieved.

Online Resource: A detailed case study is available at http://www.mntap.umn.edu/fiber/resources/83-Sunrise.htm.


Emission Reduction Modeling
Impact potential for combined process and resin change
Styrene Content 43% 38%
Atomized 254* 183
Non-atomized 102 86
* Styrene emission rate lb-styrene/ton resin processed
Styrene emissions potential: 168 pounds per ton resin processed
Yield savings: 8.4%
Material cost savings (at $0.75/lb): $126 per ton resin processed
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MnTAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

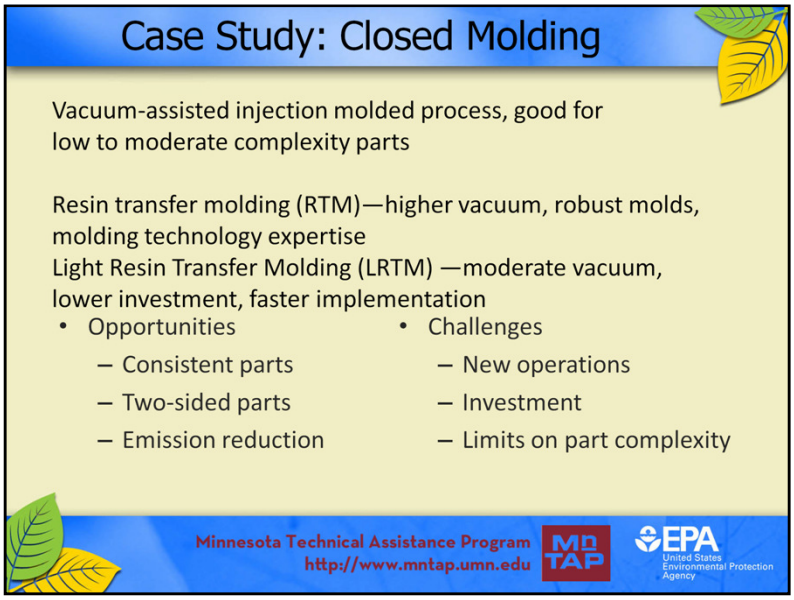
Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Say: The fiber-reinforced plastics industry has a strong industry organization—the American Composites Manufacturers Association (ACMA)—that compiles data and information for dissemination to its member organizations. This slide shows an example of a unified emission factor table that can be used to estimate emission reduction for potential improvement opportunities. The example shown ties back to the previous slide showing the emission differences estimated between the styrene content of two resins and the spray application technology deployed (atomized versus non-atomized). The emission estimates shown on this slide are all in pounds of styrene emissions per ton of applied resin.

Online Resource: A calculator is available here to help perform the associated calculations shown on this slide: http://www.pca.state.mn.us/index.php/topics/small-business-environmental-assistance-program/sbeap-resources-calculators-due-dates-and-checklists.html.


Case Study: Closed Molding
Vacuum-assisted injection molded process, good for low to moderate complexity parts
Resin transfer molding (RTM)—higher vacuum, robust molds, molding technology expertise
Light Resin Transfer Molding (LRTM) —moderate vacuum, lower investment, faster implementation
• Opportunities
– Consistent parts
– Two-sided parts
– Emission reduction
• Challenges
– New operations
– Investment
– Limits on part complexity
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MN TAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

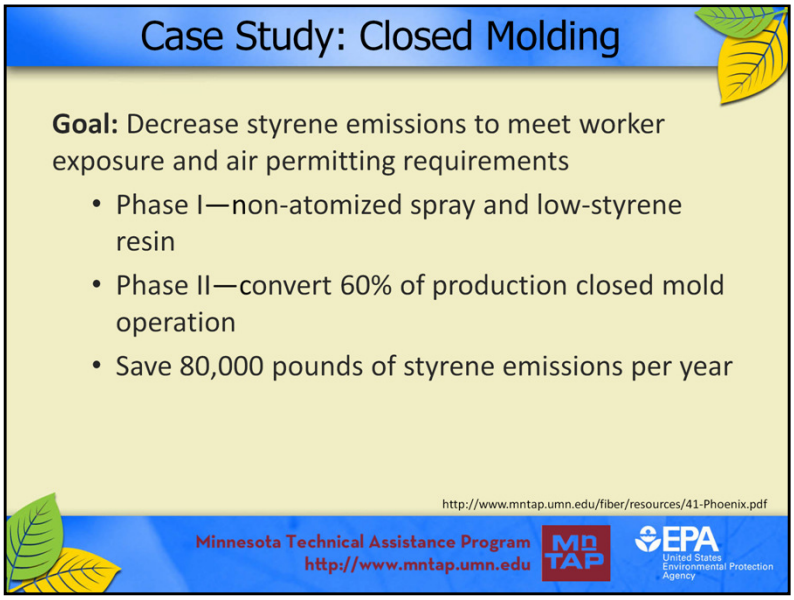
Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Instructions: Explain how, in this case study, closed molding was implemented to decrease styrene emissions and limit worker exposure.

Say: An additional resin application technology available to composite shops that can lead to significant reductions in styrene emissions is closed molding. In this case the glass mats are encased in an external mold and the resin is injected using vacuum assistance to saturate the web and create the part.

One example of this technology, resin transfer molding, involves high vacuum and requires robust molds and technical expertise for design and operation. A second example called light resin transfer molding is somewhat easier to implement, requiring moderate vacuum and lower investment in molds for faster implementation. There are both opportunities and challenges for use of this technology option.


Case Study: Closed Molding
Goal: Decrease styrene emissions to meet worker exposure and air permitting requirements
• Phase I—non-atomized spray and low-styrene resin
• Phase II—convert 60% of production closed mold operation
• Save 80,000 pounds of styrene emissions per year
http://www.mntap.umn.edu/fiber/resources/41-Phoenix.pdf
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MnTAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

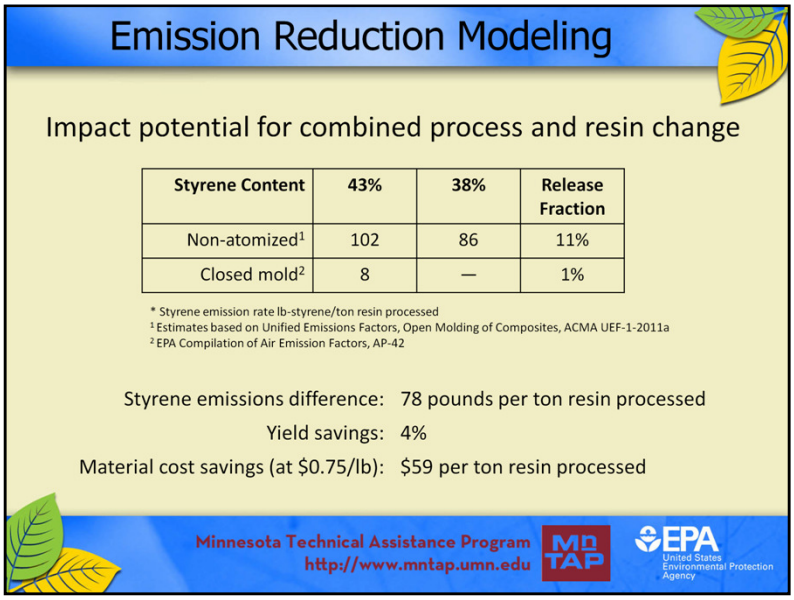
Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Instructions: This slide provides an example of a Minnesota fiberglass parts production facility who was using non-atomized spray equipment investigated use of closed mold operations to continue to decrease styrene emissions, increase material efficiency, and improve part quality.

Say: A Minnesota fiberglass parts manufacturer made a significant decrease in styrene emissions by replacing much of their optimized open molding operations with closed molding operations. This company explored options for closed molding, converting nearly 60% of their products to closed mold operations. This conversion reduced the styrene emissions by an additional 80,000 pounds per year over the reductions achieved through non-atomized spray techniques.

The company identified several challenges with closed molding, including learning new techniques and creating the molds. Effective mold design is critical for achieving consistent parts in reasonable process times. Two types of molds are used. Light resin transfer molding is a more flexible mold system used with low vacuum transfer. This system may be easier to implement to explore the technique or when fewer parts are required. Resin transfer molding requires higher vacuum and more robust molds. This system can be used when a company has experience with mold design and will use the mold for longer part runs.


Emission Reduction Modeling
Impact potential for combined process and resin change
Styrene Content | 43% | 38% | Release Fraction
Non-atomized[1] | 102 | 86 | 11%
Closed mold[2] | 8 | — | 1%
* Styrene emission rate lb-styrene/ton resin processed
[1] Estimates based on Unified Emissions Factors, Open Molding of Composites, ACMA UEF-1-2011a
[2] EPA Compilation of Air Emission Factors, AP-42
Styrene emissions difference: 78 pounds per ton resin processed
Yield savings: 4%
Material cost savings (at $0.75/lb): $59 per ton resin processed
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MnTAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

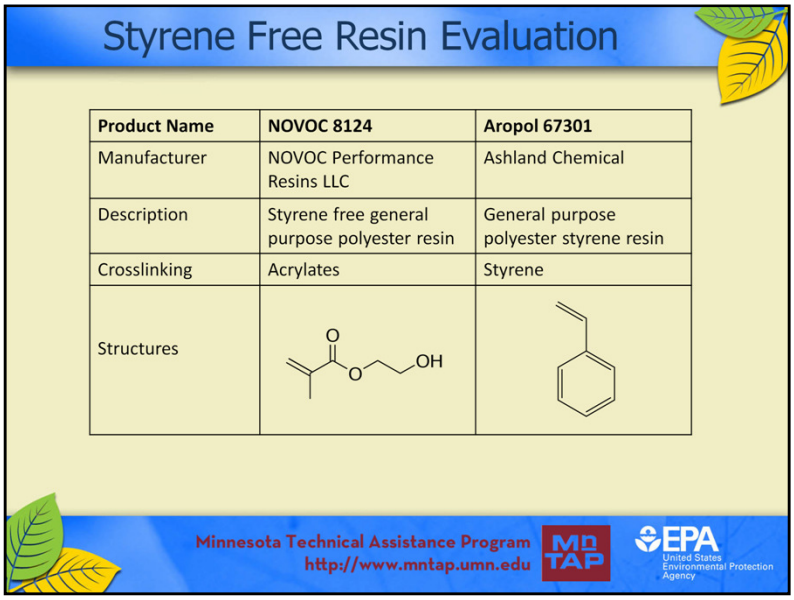
Instructions: Explain the impact potential for combined process and resin change within the context of the emission reduction model.

Say: The impact of closed molding on styrene emissions is significant. Since the resin materials are not sprayed or left to evaporate from the part surface the emission is limited to unreacted product released as the mode is opened at the end of a cycle. Typically, higher-styrene resins will be used in closed mold applications to keep the resin viscosity low for efficient transfer, but the emission estimate for styrene release is very low. The difference in styrene emission between non-atomized open mold spray technique using low-styrene-content resins and closed mold operations is approximately 78 pounds per ton of resin processed or a yield improvement of up to 4%.

Background Information:

[1] Estimates based on Unified Emissions Factors, Open Molding of Composites, ACMA UEF-1-2011a

[2] EPA Compilation of Air Emission Factors, AP-42



Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Instructions: The remainder of this presentation describes work sponsored by the Minnesota Pollution Control Agency (MPCA) through a U.S. EPA Pollution Prevention Grant from the Region V office. Through this work MnTAP has explored the opportunity to reduce styrene emissions by changing the resins used to products that do not contain styrene monomer.

Say: The Minnesota Pollution Control Agency, through a grant from U.S. EPA Region V and MnTAP, explored the opportunity to produce fiberglass-reinforced plastic parts with alternative resins that do not contain styrene. These resins may offer the opportunity to decrease hazardous air pollutant releases and decrease worker exposure to styrene.

The two resins compared are a general purpose polyester styrene resin typically used in the industry and a general purpose polyester resin as a styrene-free alternative. The structures of the two crosslinking agents used in the different resins are shown to illustrate that these resins are chemically quite different and can be expected to perform differently in applications.

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

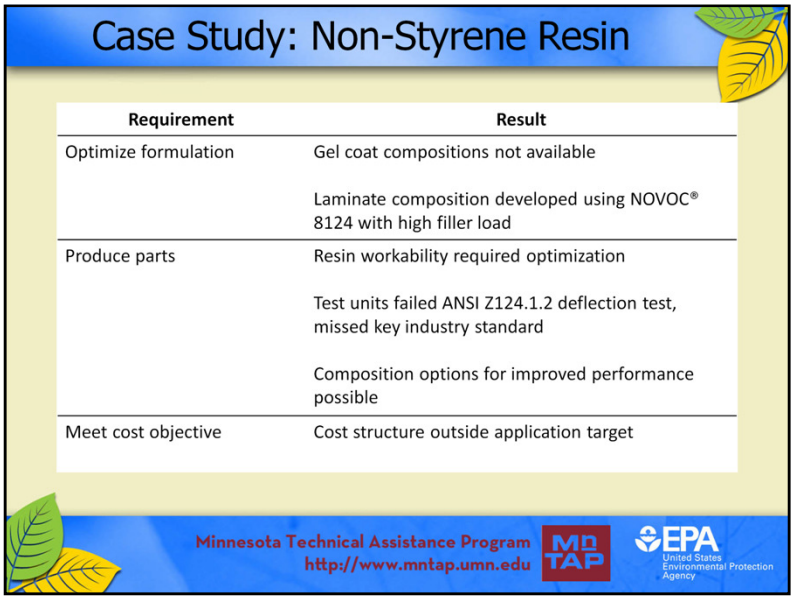
Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Instructions: Provide a brief overview of a case study for Salo Manufacturing Inc. This company is a fiber-reinforced plastics facility located in Menahga, Minnesota, that manufactures bathing systems.

Say: Salo wanted to determine whether it could economically manufacture bathtub and shower units with non-styrene resins and gel coats, and at the same time maintain the structural and cosmetic characteristics of the units manufactured with its normally used raw materials. Its ultimate goal was to come up with ways in which it could deliver the same performance at an acceptable cost while become more environmentally conscious. Reducing waste and emissions was the other primary motivation of the project.



Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

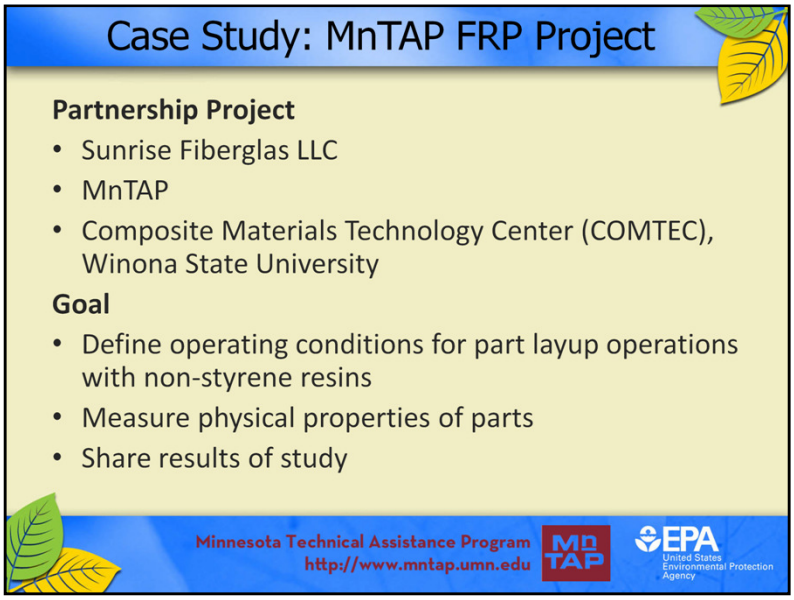
Notes for the Facilitator

Say: Salo began its project by researching several potential raw materials for testing including choices of resins, gel coats, and mold releases. With the help of a MnTAP intern, Salo researchers were able to find a styrene-free resin suitable for this application. They were not able to find a low or styrene-free gel coat.

Salo used a high filler load in their standard resin systems. The styrene-free alternative had not been developed for high filler content and required formulation testing to identify compositions that the operators could work with and performed well with existing equipment.

Test units were produced for performance evaluation. Unfortunately these units did not pass a critical industry specified test protocol for shower base deflection. After these results, it was determined that the composition could be modified further to improve deflection performance. Unfortunately this revised composition would make the formulation fall outside the target cost parameter.

Key Point: While an alternative resin was not identified during this effort, significant advances were made in formulating workable compositions with styrene-free resin alternatives, identifying ways to improve physical property performance of parts made with these resins, and training operators on how to work with these compositions. As the cost structure of the compositions improves, these alternatives will find a place in this market.


Case Study: MnTAP FRP Project
Partnership Project
• Sunrise Fiberglas LLC
• MnTAP
• Composite Materials Technology Center (COMTEC), Winona State University
Goal
• Define operating conditions for part layup operations with non-styrene resins
• Measure physical properties of parts
• Share results of study
Minnesota Technical Assistance Program
http://www.mntap.umn.edu
MN TAP
EPA
United States Environmental Protection Agency

Subtopic

Best management practices to reduce the use of chemicals of concern
30 minutes
(Elapsed time: 1 hours, 30 minutes)

Specific Outcomes

Increased awareness and use of best management practices to target hazardous substances

Notes for the Facilitator

Instructions: This slide provides a brief overview of the evaluation of a styrene-free resin system at Sunrise Fiberglass LLC. Sunrise Fiberglass manufactures custom reinforced composite components and assemblies located in Wyoming, Minnesota.

Say: Minnesota Technical Assistance Program (MnTAP) led a partnership program with Sunrise Fiberglass LLC (a manufacturer of custom reinforced composite components) and the Composite Materials Technology Center at Winona State University to produce and test the physical properties of components manufactured with styrene-free resins. The goals for this project were to define operating conditions for part production and measure physical properties for the resulting articles with the intent of sharing these results with the industry.

Background Information: The motivations behind this project were that environmental and health risks come from styrene in the resin that is released by evaporation during standard use conditions, resulting in employee exposure and releases of styrene to the environment. Project activities were set in place to allow FRP manufacturing firms to pilot the use of one styrene-free resin for controlled end use application. A webinar was held to share the findings of the project with other companies.

Trial Details
Resin comparison
– NOVOC® 8124, NOVOC Performance Resins, LLC
– Aropol 67301, Ashland Chemical
– Resins had comparable shear and gel times
Sprayed parts
– 65/35 to 80/20 glass/resin loading
– E-glass roving with silane sizing
Hand layup
– Two-layer construction
– E-glass CSM with powder binder
Observations
– Parts had good open work time
– Glass did not wet easily with resin
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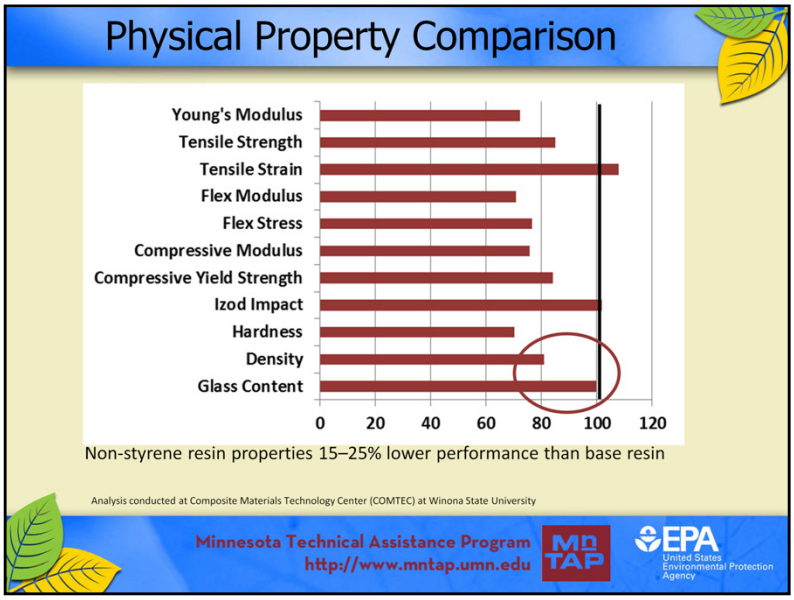
Notes for the Facilitator

Say: The trial performed a resin comparison. The resins were formulated to have comparable shear and gel times so they would perform comparably during layup and molding operations. The picture shows the hand layup formulation.

The observations made during the trial showed that the parts had good open work time, allowing for good workability and limited challenges posed by the resin formulation. However, it was observed that the glass did not wet easily.



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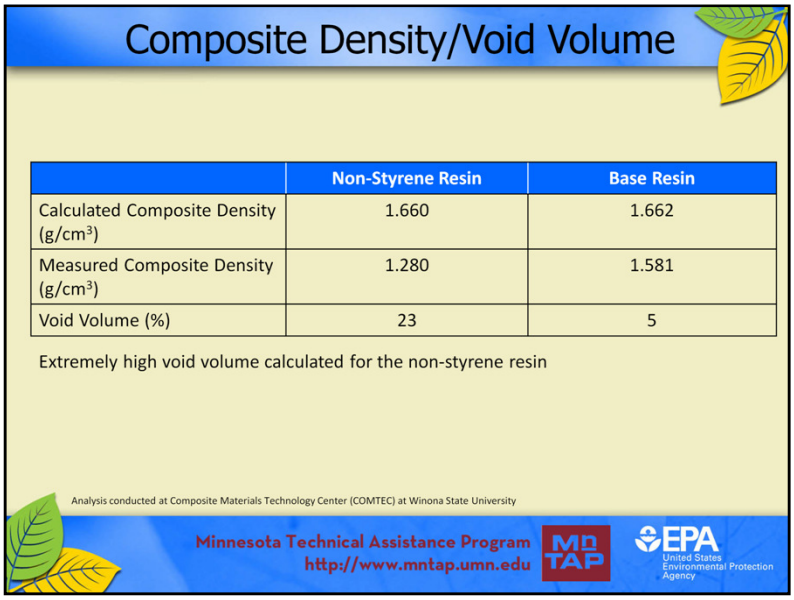
Notes for the Facilitator

Say: This slide shows the physical property comparison between the two resins. The 100 line on the right hand side represents the baseline performance of traditional resin. Each of the bars on the graph shows the relative ratio between the non-styrene resins and the traditional resin.

These resins had the same glass content, but the density was 20% lower. This is a significant difference that led the team to calculate the void volume in the parts.



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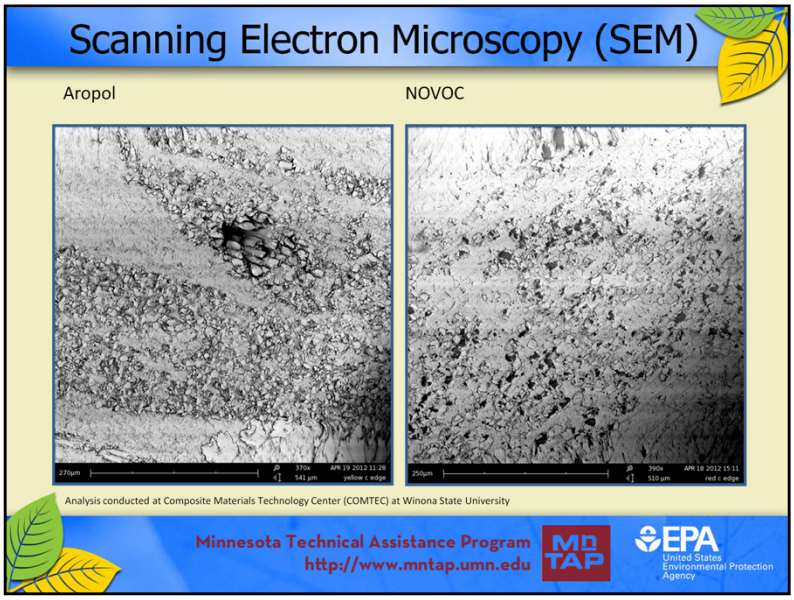
Notes for the Facilitator

Instructions: This slide displays how the void volume of the non-styrene resin was 20%, which was very high when compared to traditional base resins.

Say: Comparing the calculated composite density for an ideal structure of glass and resin with the measured values allows the estimation of the void volume of the structure. Results show that the void volume for the styrene-free resin system is extremely high, at 23%. This level of inhomogeneity in the composite structure will lead to degraded physical property performance.



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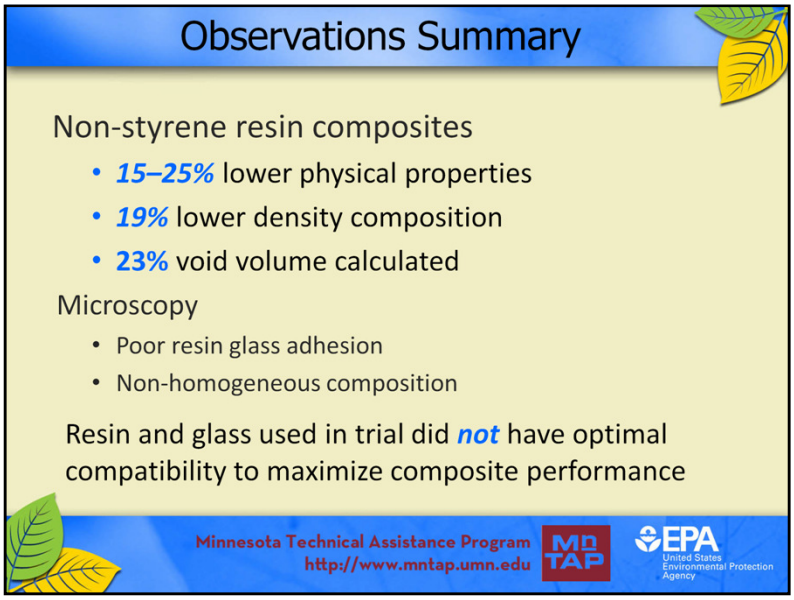
Notes for the Facilitator

Say: These electron microscope pictures confirm how the resin for the base case is well infused into the fiber bundles of the reinforcement. The styrene-free resin shows voiding throughout the structurem especially near the fiber rich areas. Other microscopy photos indicate inhomogeneous distribution of resin. These flaws in the structures will lead to poor physical property performance of a finished part.


Observations Summary
Non-styrene resin composites
• 15–25% lower physical properties
• 19% lower density composition
• 23% void volume calculated
Microscopy
• Poor resin glass adhesion
• Non-homogeneous composition
Resin and glass used in trial did not have optimal compatibility to maximize composite performance
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Notes for the Facilitator

Say: This slide shows the results of the comparison trials for the two non-styrene resins and traditional resin. The results showed that the glass and the resins in this trial were not compatible.

Phase III Proposal
Goal: Define use and performance ranges for non-styrene resins using a design of experiment approach
• Collaborate—university, industry, supplier partners
– Generate performance results for alternate resin/composite compositions
– Identify optimal performance from lab data
• Transferrable outcomes
– Test best compositions in FRP shop process
– Compare performance with incumbent resins
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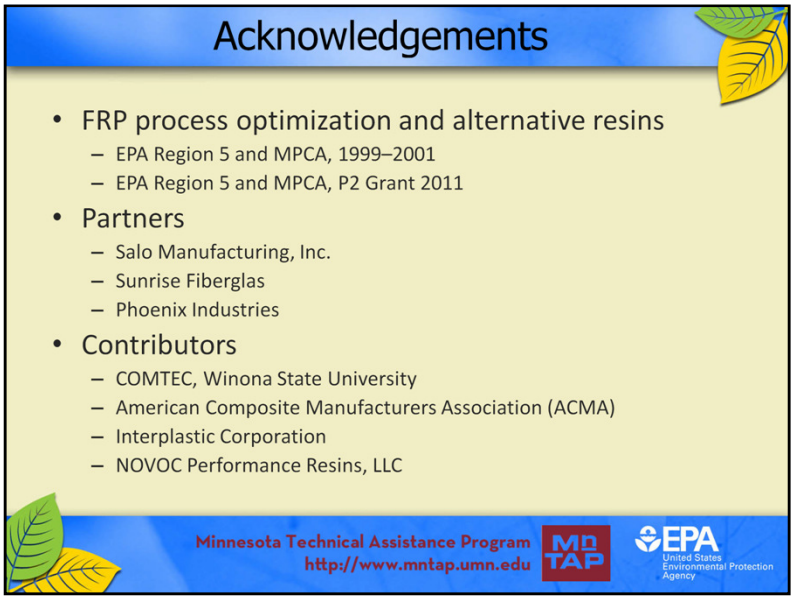
Say: This slide outlines an approach to develop compatible composite systems with styrene-free resins. Specifically, the proposed work would test a range of composition variables to identify optimal composite performance from laboratory data. This screening could be followed with demonstration parts production in a shop to determine how the performance translates from the laboratory to commercial production conditions.



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Notes for the Facilitator